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GB 1441945 A EP 0111604 A1 WO 90/13950 A1

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(54) Abstract Title
Mains signalling transient suppression

(57) A mains power line signal coupler circuit comprising a mains connection section, a coupling section 103, and a data connection section wherein 107 the data connection section comprises transient suppression means 107 arranged to suppress transients originating from the mains connection section.

The present invention also provides an improved signal coupler housing and method of installation (Figs. 2-6, not shown).

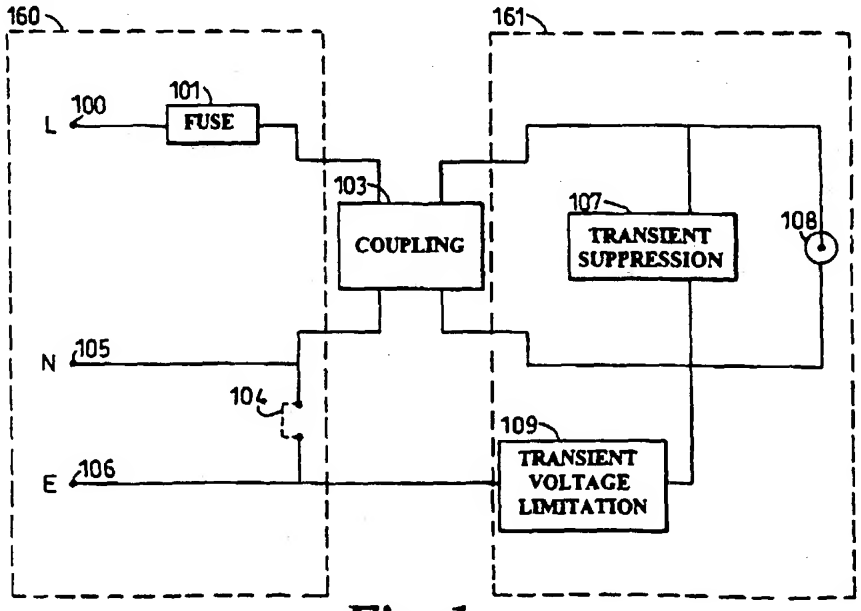

Fig. 1

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

The print reflects an assignment of the application under the provisions of Section 30 of the Patents Act 1977.

GB 2 341 776 A

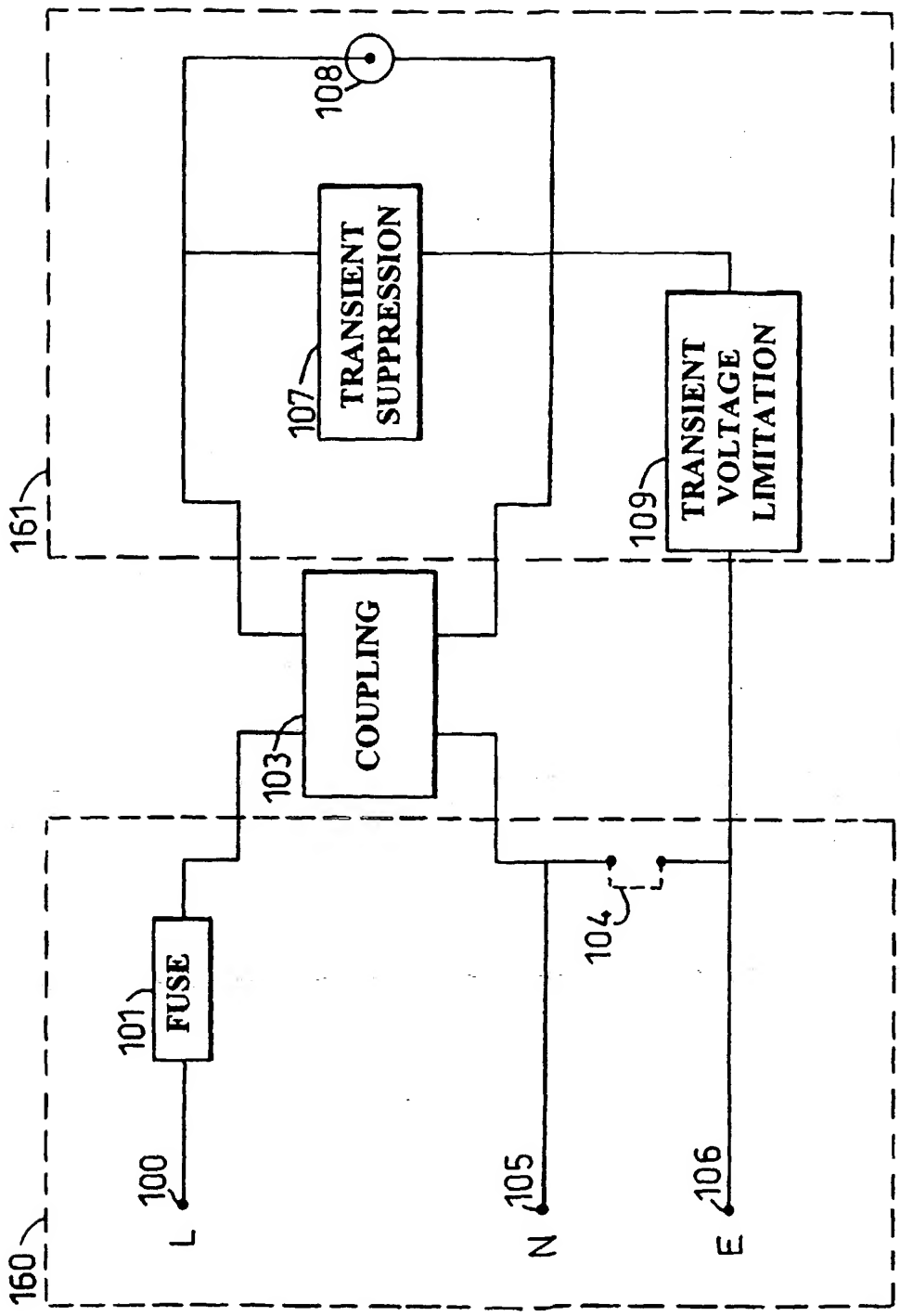

Fig. 1

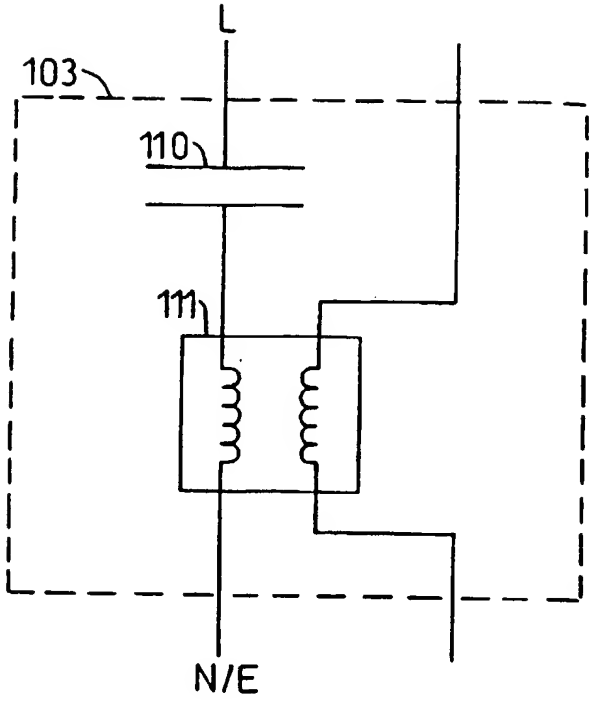

Fig. 1a

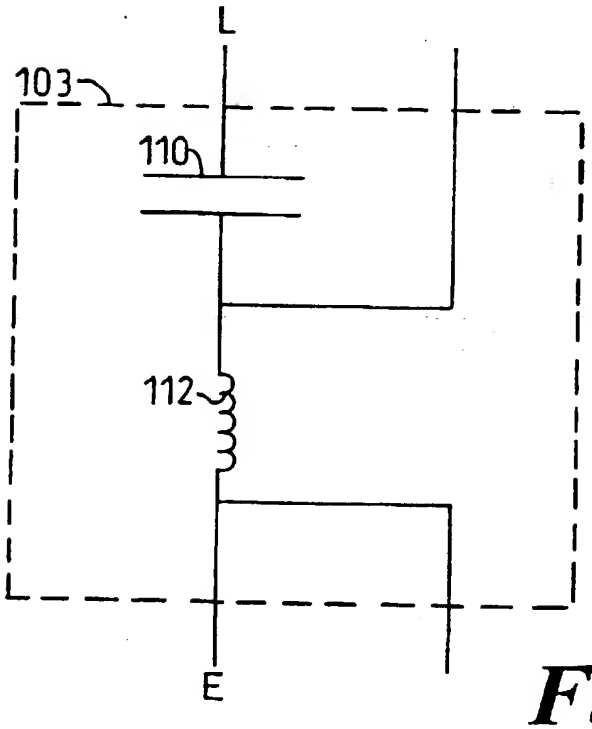

Fig. 1b

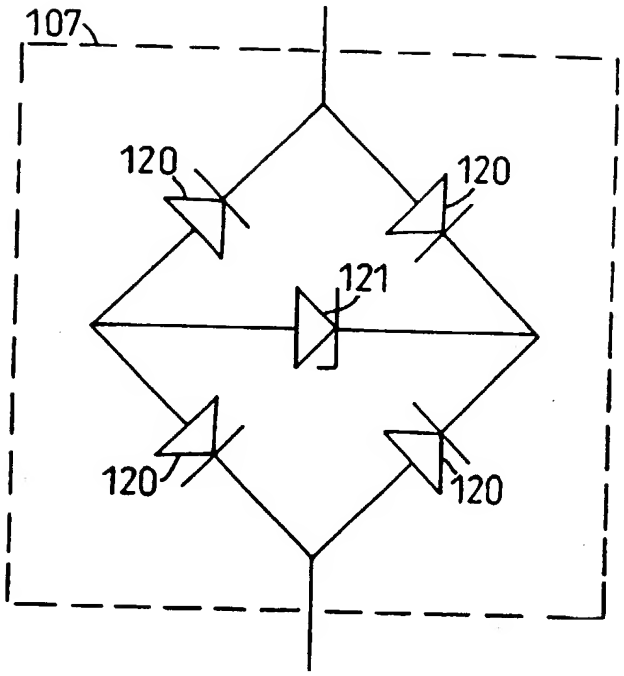

Fig. 1c

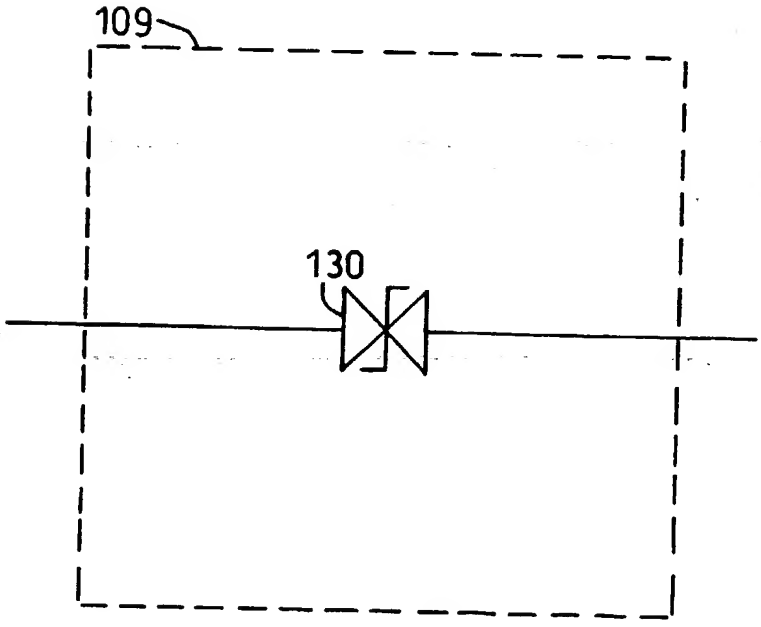

Fig. 1d

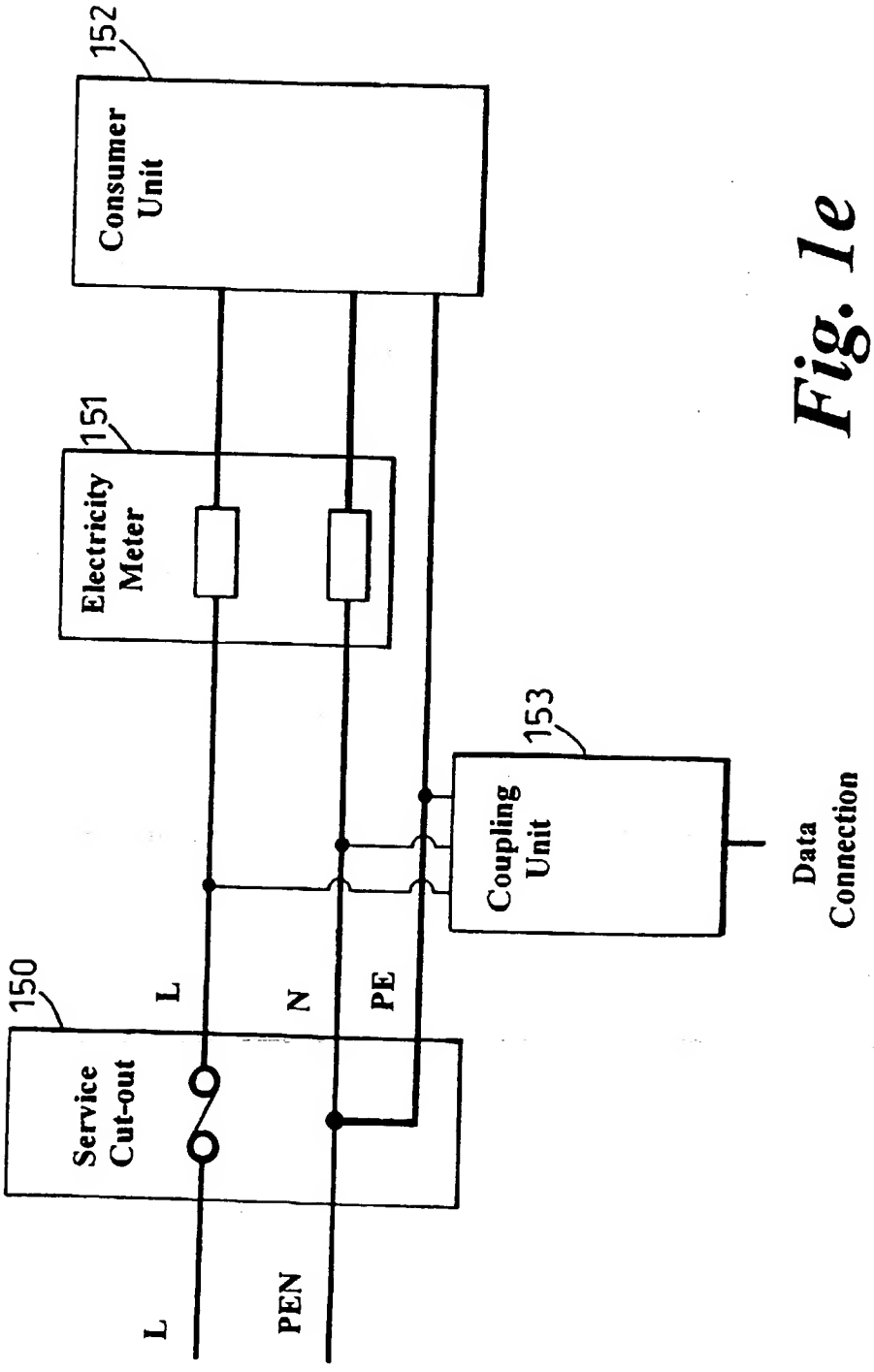
152
Consumer Unit
151
Electricity Meter
153
Coupling Unit
Data Connection
150
Service Cut-out
L
N
PE
L
PEN

Fig. 1e

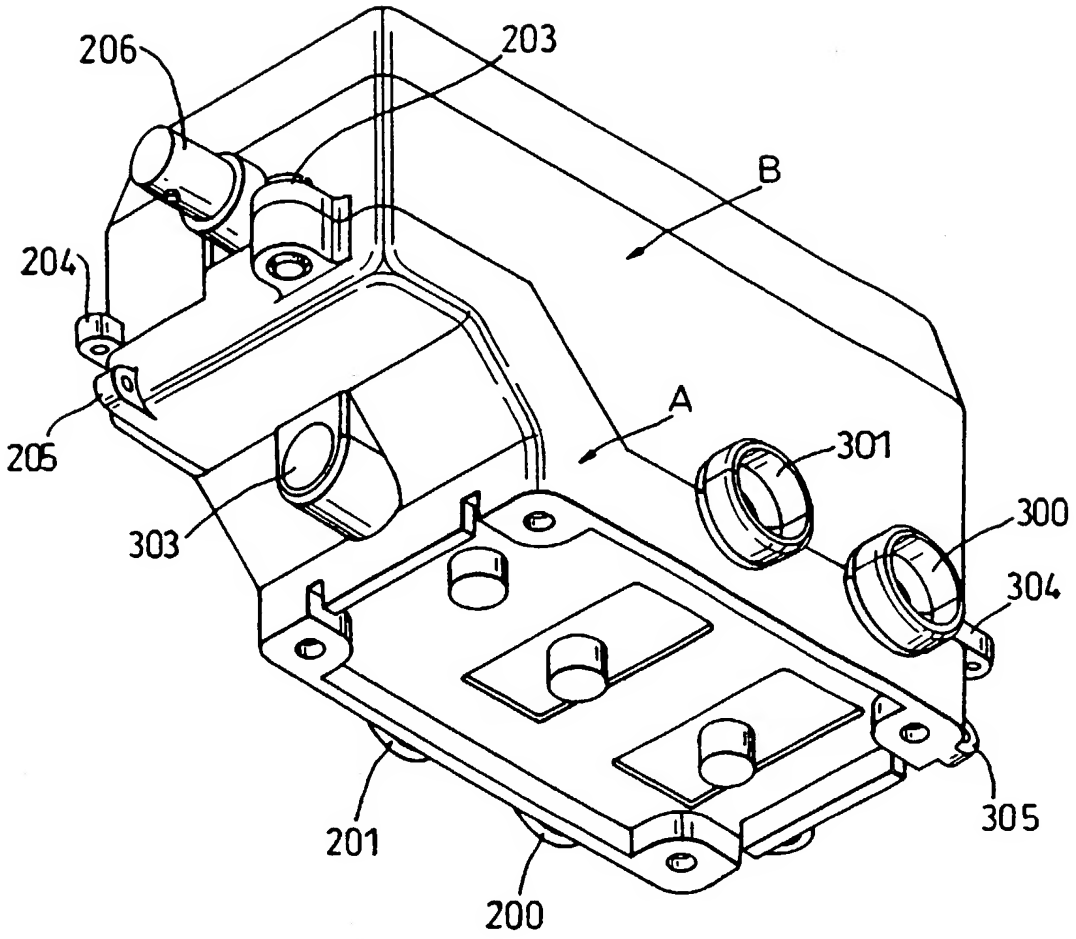

Fig. 2

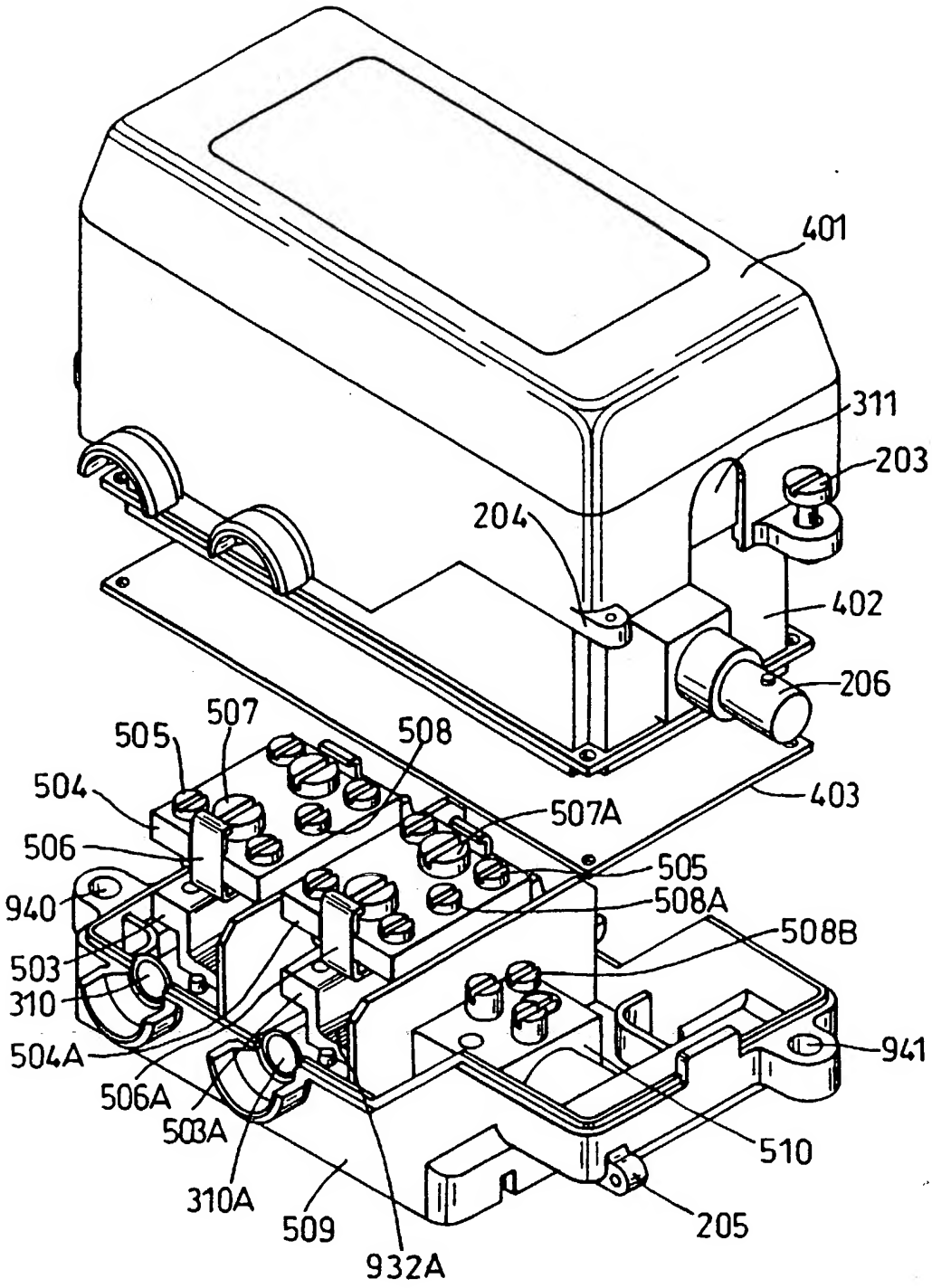
401
311
203
204
402
206
507
505
508
504
507A
506
505
940
508A
508B
503
310
941
504A
506A
503A
510
310A
509
205
932A

Fig. 3

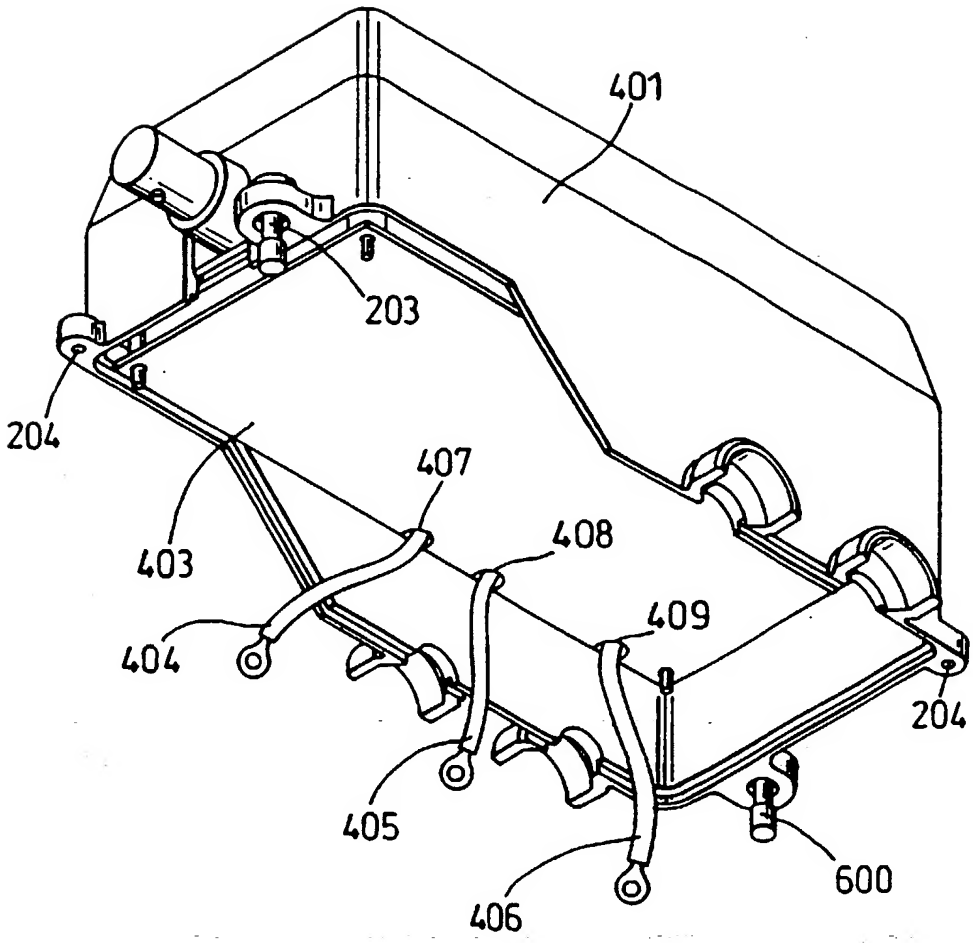

Fig. 4

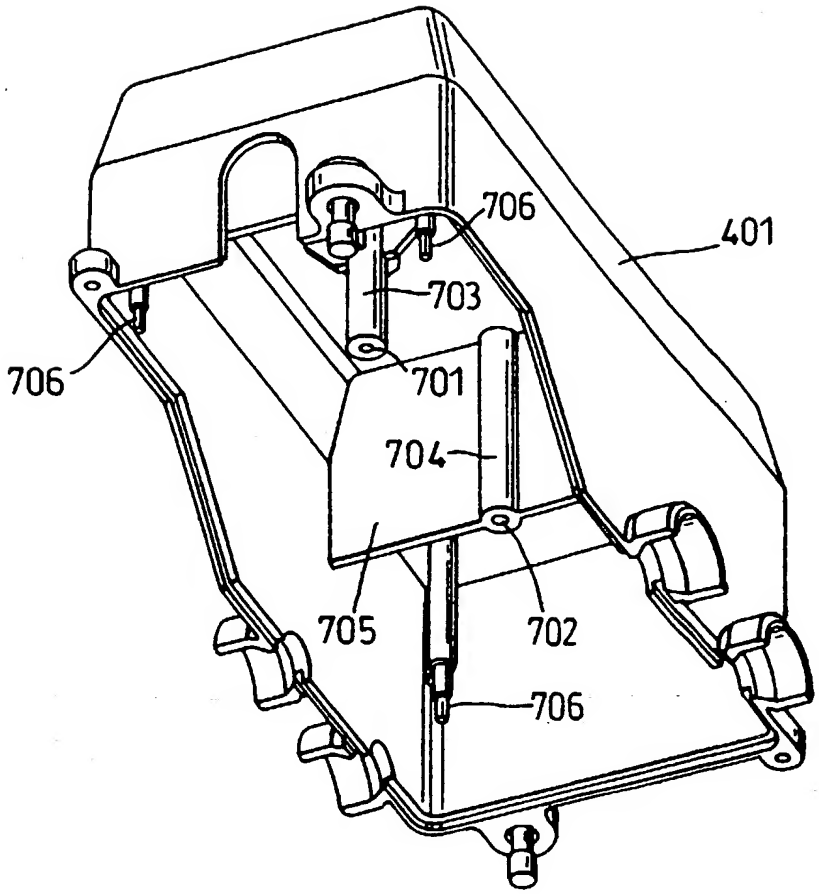

Fig. 5

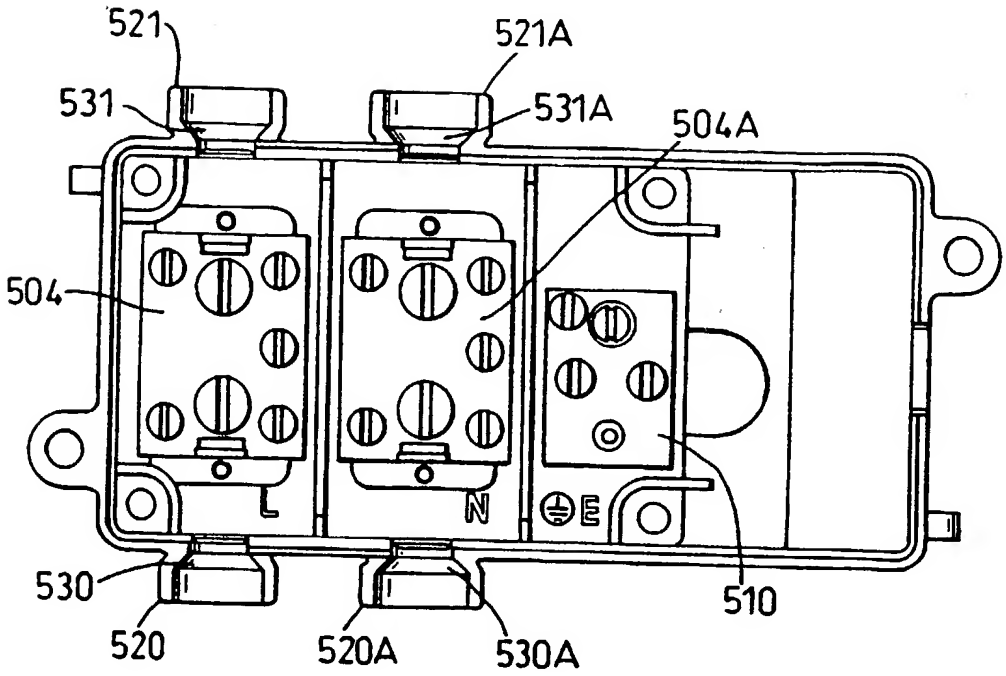
521
521A
531
531A
504A
504
L
N
E
530
520
520A
530A
510

Fig. 6a

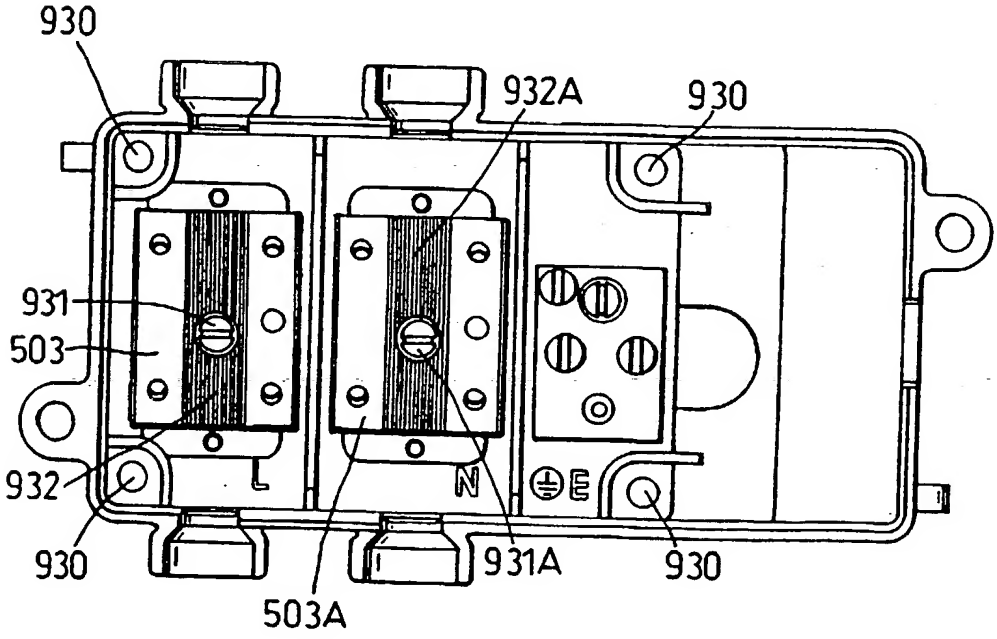
930
932A
930
931
503
L
N
E
932
930
931A
930
503A

Fig. 6b

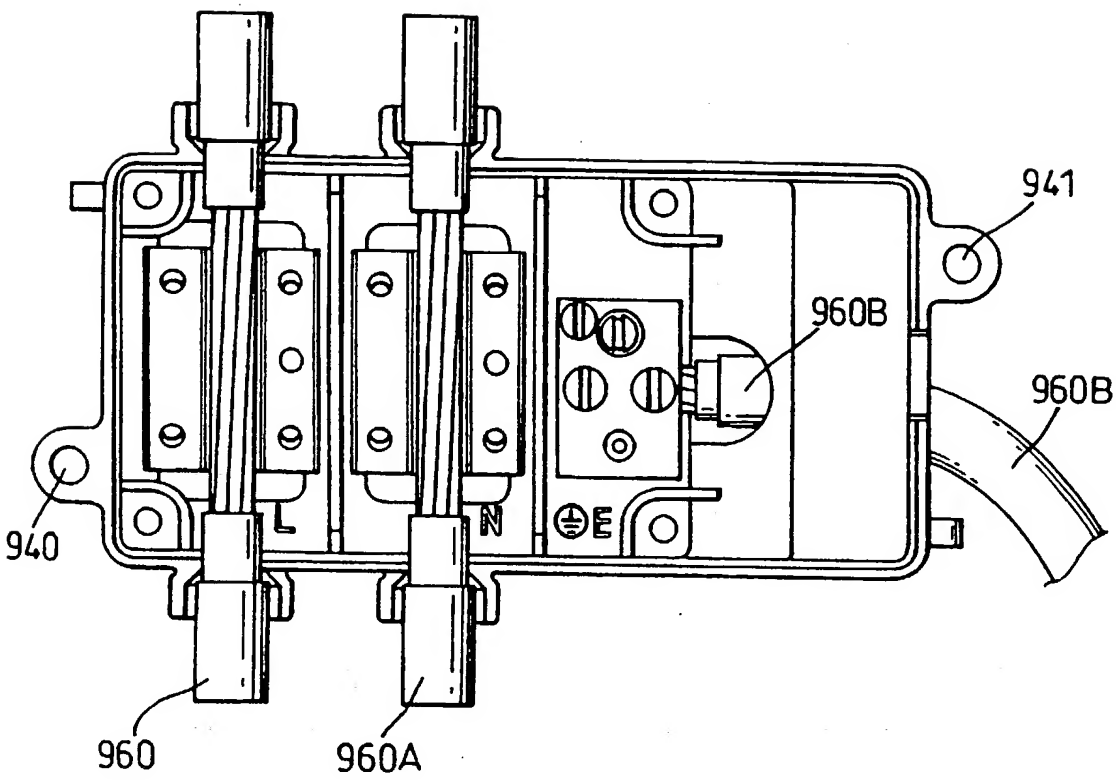

Fig. 6c

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TELECOMMUNICATIONS SIGNAL COUPLER APPARATUS AND METHOD

FIELD OF THE INVENTION

This invention relates to transmission of communications signals over power lines.

BACKGROUND OF THE INVENTION

Patent Application WO 94/09572 A1 (Norweb) describes a network to transport telecommunications signals over an electricity distribution or power transmission network. Delivering a telecommunications service in this manner appears attractive as it avoids the need to install new cabling to each subscriber. By using existing electricity distribution cabling to carry telecommunications signals, significant cost savings are possible.

Provision of a signal coupler unit incorporating mains conditioning components has several inconveniences: the power cable is severed, and the electricity supply must be switched off while installation of the unit takes place and some further work is often necessary to accommodate it.

A problem with transporting telecommunications signals over an electricity distribution network is the effect of transient voltages in the mains supply on the telecommunications equipment attached thereto. Patent Application GB 9610266.0 proposed to construct a signal coupling unit which provides transient suppression on the mains connection side of the coupler, by using a metal oxide varistor (MOV) and a gas discharge tube connected in series across the mains supply. Such components are large and expensive, and in the case of the MOV, are prone to degrade over time.

OBJECT TO THE INVENTION

The present invention seeks to provide an alternative arrangement for coupling signals to and from a power line which overcomes the problems outlined above.

The present invention also seeks to provide an improved method of installing and removing apparatus for coupling signals to and from a power line.

SUMMARY OF THE INVENTION

According to a first aspect of the present invention, a mains power line signal coupler circuit comprising a mains connection section, a coupling section, and a data connection section wherein the data connection section comprises transient suppression means arranged to suppress transients originating from the mains connection section.

Advantageously, the transient suppression means is connected across the data terminals of the coupling section.

Advantageously, the transient suppression means comprises a voltage clamping diode within a diode bridge.

According to a further aspect of the present invention a communications network in which power and communications signals are carried over power lines, and comprising a signal coupler circuit according to the present invention

According to a further aspect of the present invention, a signal coupler comprising a mains connector part and a signal coupler part, wherein said parts are separable one from the other and arranged to provide electrical connection between said modules.

Advantageously, the mains connector part comprises at least one mains connector and a housing therefor, and the signal coupler part comprises a signal coupler circuit and a housing therefor.

Advantageously, a mains connector is arranged enable lead-though connection to a mains supply cable.

Advantageously, Live and Neutral mains connectors are each arranged to enable lead-though connection to a mains supply cable.

Advantageously, the mains connector comprises a opening cover and cable clamping means.

According to a further aspect of the present invention there is provided a signal coupler for coupling telecommunications signals between telecommunications equipment and a mains power cable, comprising a closed insulated housing, a first connection terminal mounted in a housing and having a channel for accommodating the mains power cable conductor, a clamp for clamping the conductor in the channel, the housing supporting a second connection terminal for connection to an earth lead and a third connection terminal for connection to the telecommunications equipment, the housing enclosing a circuit connected between first, second, and third terminals enabling telecommunications signals to pass between the first and third terminals and isolating the mains supply voltage from the third terminal.

According to a further aspect of the preseten invention there is provided a method of installing a signal coupler according to claim 5 comprising the steps of: providing a signal coupler and a length of mains cable;baring a mid-portion of said mains cable;opening the cover of a mains connector of said signal coupler unit; locating said bared section of mains cable along said mains connector; closing the cover of said mains connector; clamping said bared section of mains cable by clamping means of said mains connector.

Advatangeously, the signal coupler unit is according to any of claims 5-11:

According to a further aspect of the present invention there is provided a method of removing a signal coupler unit according to the present invention comprising the steps of : detaching the signal coupler part from the mains connection part; attaching a blanking cover in place of said signal coupler part.

According to a further aspect of the present invention there is provided an signal coupler according to the present invention, comprising a power line connector comprising cable clamping means and arranged to accept, retain by said clamping means, and make electrical contact with a bared mid-portion of an electrical cable which cable is elsewhere retained by arbitrary means towards each end of said cable.

Advantageously, the electrical connector is arranged to accept, retain by said clamping means, and make electrical contact with and between bared end-portions of two electrical cables.

Advantageously, the electrical connector additionally comprises cable surface corrosion penetrating means.

Advantageously, the electrical connector cable surface corrosion penetrating means comprise ridges formed on a cable-facing surface of the connector.

Advantageously, the ridges are formed parallel to the line of insertion of the electrical cable.

Advantageously, the present invention does not require conditioning of the mains connection, thereby reducing both size and cost of the apparatus.

Advantageously, the present invention does not require the main cables to be cut, thereby avoiding interruption of the power supply during installation.

Advantageously, the separability of the unit housing parts enables independent fitting of the mains connector unit, with a blanking cover, in new-build situations, whereby to facilitate rapid data connection installation at a later date by replacement of the blanking cover by a signal coupler.

Advantageously, the separability of the unit housing parts permits rapid disconnection and removal of the signal coupler portion and replacement with a blanking cover.

The invention is also directed to a method by which the described apparatus operates and including method steps for carrying out the function of the apparatus.

The invention also provides for a system for the purposes of digital signal processing which comprises one or more instances of apparatus embodying the present invention, together with other additional apparatus.

The preferred features may be combined as appropriate, as would be apparent to a skilled person, and may be combined with any of the aspects of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

In order to show how the invention may be carried into effect, embodiments of the invention are now described below by way of example only and with reference to the accompanying figures in which:

Figure 1 shows a circuit diagram of a signal coupler in accordance with an embodiment the present invention;

Figures 1a and 1b show alternative embodiments of the coupling means shown in the circuit of Figure 1;

Figure 1c shows a specific embodiment of transient suppression means shown in the circuit of Figure 1;

Figure 1d shows a specific embodiment of transient voltage limitation means shown in the circuit of Figure 1;

Figure 1e shows a typical installation point of a signal coupler unit in accordance with Figure 1;

Figure 2 shows a perspective view of the signal coupler;

Figure 3 shows a general exploded perspective view of the signal coupler;

Figure 4 shows a perspective view of the signal coupler part;

Figure 5 shows a perspective view of the housing part of the signal coupler part of Figure 4;

Figure 6a shows a plan view of the mains connector part with terminal covers in place;

Figure 6b shows a plan view of the mains connector part with live and neutral terminal covers removed;

Figure 6c shows a plan view of the mains connector part with live and neutral terminal covers removed and sections of stripped live and neutral mains cable located in position.

DETAILED DESCRIPTION OF INVENTION

Referring to Figure 1, the signal coupler circuit is shown comprising a mains connection section (160), a data connection section (161), and coupling section (103) wherein the mains connection circuit comprises three terminals (100, 105, 106) for connection to the mains live, neutral, and earth respectively, and the data connection section comprises transient suppression circuit means (107), common mode transient voltage limitation means (109), and a data connection terminal (108).

The mains connection section comprises three low-voltage (for example 240V, 50Hz) power supply connectors (100, 105, 106), a fuse (101), and a switch (104). The live (or "phase") mains connector (100) is connected in series via the fuse (101), and the data coupling unit (103) to the neutral mains connector (105).

The switch (104) provides optional connectivity between the earth connector (106) and the neutral connector (105). Connection can be made therefore either between the phase and the protective earth or between the phase and neutral: the choice of connection will largely depend on the types of power arrangements in different countries and the type of power network installed there. In a preferred embodiment, the switch is implemented as an optional connection path, either installed or omitted during manufacture.

The fuse (101) is provided for overload protection.

The coupling section (103) provides coupling of the RF signals between the mains connection section and the data connection section, whilst preventing coupling of mains frequency signals.

In a first embodiment of a coupling section in accordance with the present invention, shown in Figure 1a, the mains live connection is connected via a capacitor (110) and the primary windings of a transformer (111) to the mains neutral or protective earth connection.

The capacitor (110) is chosen to provide a relatively high impedance at low frequencies (for example 50-60Hz) but a relatively low impedance at the RF frequencies (for example 1 - 20MHz) used to transmit data. At the lower frequencies the current flowing through the transformer (111) under normal circumstances is small and consequently the transformer can also

be small. The capacitor (110) needs to be selected to be suitable for the working mains voltage and the likely transients and must take into account the applicable national or other regulatory safety requirements.

If connection is to be made only between the live and protective earth, then a suitably rated Y capacitor (110) should be used; if connection is to be made only between the live and neutral, then either a suitably rated X capacitor (110) or a suitably rated Y capacitor could be used; if the connection might be made either between the live and the protective earth or between the live and neutral, then a suitably rated Y capacitor should be used.

The secondary windings of the transformer (111) are connected to the data connection section.

The fuse (101) provides protection in the event of the capacitor (110) short circuiting and the fuse (101) and transformer (111) should be selected such that in the event of the capacitor (110) short circuiting, the fuse open circuits before the transformer is damaged.

The transformer (111) provides a method of reliably transferring the data signal and has the additional advantage of providing electrical isolation between the mains connection circuit and the data connection circuit. In a preferred embodiment the transformer has a 1:1 ratio between the primary and secondary windings, but other ratios may also be selected.

An alternative to the coupling section of Figure 1a is shown in Figure 1b, in which the mains live connection is connected via a capacitor (110) and an inductor (112) to the protective earth connection. The data connection section feeds are connected across the inductor (112).

This alternative is appropriate where it is known that the mains connection circuit is connected to protective earth, and whilst it provides coupling between the mains connection circuit and the data connection circuit, it does not provide electrical isolation. If the earth end of the mains signal is known to be protective earth, then other means of transferring the signal, such as suitably rated capacitors, could be used.

The approach of Figure 1a has the advantage of being applicable whether the mains connection section is connected to neutral or to protective earth. This potentially enables economies of scale in manufacture.

The data connection circuit comprises a transient suppression unit (107), a data connector (108) and a common mode transient voltage limiting unit (109). The transient suppression unit (107) and the data connector (108) are connected in parallel across the data connections of the coupling unit (103), whilst the common mode transient voltage limiting unit (109) connects the data connection circuit to protective earth (106).

The transient suppression unit (107) provides a low capacitance load under normal conditions but acts to provide differential mode transient voltages that can appear across the coupling unit's data secton terminals.

In a preferred embodiment, the transient suppression unit (107) comprises a bridge comprising four diodes (120) and a voltage clamping diode (121) as shown in Figure 1c. Alternative embodiments include, but are not limited to, either a gas discharge tube or a diode bridge with a metal oxide varistor.

Provision of the transient suppression unit in the data connection section rather than in the mains connection section has the advantage that smaller, less expensive components may be used.

In a preferred embodiment, the common mode transient voltage limiting unit (109) comprises a bi-directional voltage clamping diode (130) as shown in Figure 1d. Other embodiments that could perform this function include metal oxide varistors or a circuit comprising one or more gas discharge tubes.

Depending both on the characteristics of the equipment to be connected to the data connector (108) and on the cable arrangement between the data connector and the equipment which generates and receives the RF signal, it may also be appropriate either to directly earth one side of the RF output or to float both sides with respect to ground.

The signal coupler as a whole enables two-way communication utilising an RF signal via an AC mains distribution network linking a consumer's home to the power utility's electricity sub-station.

The electrical design of the signal coupler using a transformer (111) as described above ensures that the AC mains connection section (160) is safely isolated from the RF signal output section (161). The circuit also ensures that transients which can appear on the AC mains supply, and

therefore be coupled to the RF output, are suppressed (107) without disrupting the desired RF signal.

The signal coupler is intended to meet the electrical and safety requirements of many countries by means of simple modifications of a few connections.

The circuit is capable of being connected to both a TN and a TT power system and, in a preferred embodiment, is arranged, inter alia, for operation on unconditioned underground power lines using frequency diversity bands PLT1 and PLT2, radio frequency (RF) FSK modulation, and an appropriate protocol to provide up to the order of 1 Mbps peak bit rate shared between all Customer Premises Equipment (CPE) connected to a given basestation.

A signal coupler is arranged to be connected to a high current mains electricity supply to, for example, domestic premises as shown in Figure 1e. The signal coupler unit (153) is arranged to be connected to the mains supply between the local service cut-out fuse (150) and the electricity meter (151) and consumer unit (152). This part of the mains supply is commonly located in a small cupboard with limited space available for installation of additional equipment, both on account of apparatus such as the meter or consumer unit already located there and on account of the multiplicity of electricity cables entering and leaving the area. It is therefore important that the coupler be as compact as possible both in overall dimensions and, especially, in terms of its attachment footprint.

A signal coupler in accordance with the present invention may also be connected at the basestation end of the mains connection, typically located at or near an electricity substation. The electrical interface is identical to that described above except that some components may need to be up-rated for the basestation variant to cater for the increased frequency of transients expected.

In a preferred embodiment, a common mechanical design of the signal coupler unit is used for coupling either at the basestation or the subscriber unit.

Referring now to Figure 2, there is shown the exterior of a signal coupler. Apertures are provided for insertion of mains live cable (200, 300), main neutral cable (201, 301) and earth cable (303). A co-axial socket (206) is provided for connection to a local data circuit, though alternative data connectors may be employed.

The signal coupler unit comprises two separable parts: a mains connector part (A) and a signal coupler part (B). The signal coupler part (B) houses the signal coupler circuit, such as that described above, that provides the electrical isolation between the RF signal and the mains supply.

Figure 3 shows an exploded view of the signal coupler showing the relationship between the mains connector part (A) and the signal coupler part (B). The signal coupler part (B) comprises a housing part (401), circuit board (402) (incorporating data connector (206)) and electrically insulating base cover plate (403).

The housing part (401), as shown in Figure 5, is injection moulded in a thermo-plastics material and comprises two screw fixing points (701, 702) for attachment of the circuit board (402) to the housing. Circuit board spacers (703, 704) serve to distance the circuit board components from the housing part. The housing also comprises a baffle (705) arranged so that, when the circuit board is in position, it provides a physical barrier between the signal coupler fuse (101), whereby to protect the rest of the signal coupler circuitry in the event of the fuse blowing.

The housing part also comprises means to locate the base cover plate (403) to the housing (401). In a preferred embodiment, this comprises pegs (706) integral to the housing moulding and arranged to be located through corresponding apertures in the base cover plate (403); the ends of the pegs may then be welded to the base cover plate to fix the base cover plate in place. Attachment in this way is both cheaper than alternative screw fixings and improves electrical safety by avoiding a introduction of an unnecessary electrical path between the mains connector part (A) and the signal coupler part (B).

The mains connector module and the signal coupler module are secured together by screws fixings (203, 600) secured through threaded holes (941, 940) respectively, and the unit can be sealed with a security wire and lead tag or seal. The holes (204, 205, 304, 305) that enable fixing by

means of security wire are positioned so as to prevent inadvertent entry of the sealing wire to the interior of the unit. Dimensions of the security wire and additional requirements regarding the material surrounding the hole should conform to local regulatory requirements. Access to internal parts of the unit is only possible once the above securing means have been removed.

The mains connector part (A) is arranged to be affixed to a base-board using screw fixings such that the screw fixings, once fitted through the pre-formed screw holes (930), are only accessible when the signal coupler part (A) has been detached from the mains connector part (B).

The exterior housing parts (401, 404) of each module, and the base cover plate (403), are preferably constructed from fire-retardant plastics material which meets national electrical insulation and safety regulatory requirements. The enclosure also preferably meets national regulatory requirements for impact and steady force tests.

Those parts of the housing adjacent the mains connection preferably withstand the temperature of arcing parts nearby up to a temperature of, for example, 135 °C, so as to meet regulatory requirements. Preferably the thickness of plastic parts, and creepages and clearance distances between mains connected parts and accessible parts are sufficient to provide Reinforced Insulation to meet national regulatory requirements.

Preferably, the housing simultaneously meets such requirements for a range of countries whereby to allow economies of scale in manufacture.

The housing makes provision with knock-outs (310, 310A) for live and a neutral cables respectively; a similar knockout may be provided in the earth-cable aperture (303). In an alternative embodiment, knock-outs are arranged for an overall jacketed cable (for example a single cable as in Germany).

Where the housings are manufactured from a thermo-plastics material, conventional knock-outs, having a continuous thinned portion surrounding the potential aperture, may be ineffective, owing to the flexibility of the thermo-plastics material. This problem is overcome by forming perforations within the thinned portion surrounding the potential aperture, so that during installation, the knock-outs may be detached by successive

cutting or tearing of the necks which remain between the perforations and which join the knock-out to the housing proper.

The coupler is capable of being connected in one of two configurations: 'pass-through' connection and 'lead-in' connection.

Referring now to Figures 3, 6a, 6b, and 6c, 'pass-through' mains terminals are shown, each comprising a conductive block (503, 503A) defining live and neutral mains cable channels respectively, a terminal cover (504, 504A), screw fixings (505) to attach the terminal covers to the blocks, clamping plates (506, 506A) and a pair of clamping screws (507, 507A), and secondary electrical connection points (508, 508A). The cable channel defining block (503) is attached to the module housing (509) by further screw fixings (931, 931A).

During connection of the module to the mains power supply, the terminal covers (504, 504A) are removed to reveal the cable channel as shown in Figure 6b. A length of mains cable (960, 960A) proportionate to the length of the connector block is bared and located in the cable channel, and the covers re-secured in place. The cables are then clamped in place by tightening the clamping screws (507, 507A). A separate clamping plate (506, 506A) may be interposed between the clamping screws (507, 507A) and the bared cable (960, 960A) to spread the pressure and reduce potential damage to the conductive element of the cable. Provision of such a clamping plate is necessary to meet some national requirements.

In the 'pass-through' configuration the mains current may continue to be carried by the interconnecting wires: it is preferable not to cut the wires and terminate them in this unit since this avoids interruption to the power supply during installation. In situations where it is necessary to cut the cable (for example where the coupler unit cannot be physically located between the fuse and meter) the connections are designed to withstand a continuous current equivalent to that expected to be drawn on the mains supply at that point, for example 100 A.

The 'pass-through' connection is intended for locations where the mains cables come from the incoming supply at the company fuse / house service cut-out (150), through the signal coupler unit (153) and then terminate in the electricity meter (151) as shown in Figure 1e.

The 'lead-in' mode of connection may be used in locations where dedicated cables are supplied to the unit from the incoming mains supply, whether from the electricity meter or from the company fuse / house service cut-out.

The protective earth connection terminal (510) is designed to permit of 'lead-in' connection of the earth cable (960B).

Alternative designs of mains terminals may be provisioned according to the anticipated mode of use described above: in a first preferred embodiment a low-cost connection block is provisioned that allows only 'lead-in' connection; in a second preferred embodiment, a connection block that will support both 'pass-through' and 'lead-in' connection is provisioned for versatility.

Cable guide 'collars' (520, 520A, 521, 521A) are provided at the live and neutral cable entry points. These collars have narrowed portion (530, 530A, 531, 531A) at the housing end of the collar. These narowings are designed to meet electrical safety requirements to prevent insertion in to the apparatus of a probe of greater than 1mm diameter alongside the cables. Additionally, the sheathed portion of mains cable to each side of the bared section of the cable is prevented, once installed, from being pushed into the housing.

The design of PCB and enclosure may remain unchanged irrespective of which connection block is fitted. If the 'lead-in' connection only terminals are fitted, it is technically possible to exchange them for the 'lead-through' terminals at the time of installing the unit: this caters for situations where no spare terminals are available at the electricity meter or house service cut-out.

The design allows a 'pass-through' connection (appropriate inter alia to the UK market) in which the live and neutral conductors enter on one side of the housing and exit on the opposite side. The design ensures that the connection means makes good contact with the live, neutral and protective earth conductors.

In many cases using a TN supply only two terminals will be used. To save material and assembly cost the product can be sub-equipped in the factory with only the relevant terminals for a specific customer, e.g. for

most UK installations only one Live and one Protective Earth terminal are used.

For some markets (for example Germany) an extra insulated section may be used to provide sufficient wiring space to enable safe termination of the double-insulated feed to the connectors. This item will interlock with the rest of the unit and will also provide the necessary environmental protection.

The unit is capable of connection to the Live, Neutral, and Protective Earth supply leads. The connections between the signal coupler part (B) and the mains connection part (A) are preferably via flying leads (404, 405, 406) to the secondary electrical connection points (508, 508A, 508B). The flying leads pass through apertures (407, 408, 409) in the base cover plate (403). These apertures are located at the edge of the base cover plate for ease of assembly. The design ensures that a breakage or displacement of any metal component within the mains connection part (including the connection means from the RF part) will not result in a short circuit condition.

In a preferred embodiment, live and neutral terminals accommodate wires having a range of cross-sectional areas, for example between 6 sq. mm and 35 sq. mm, and the protective earth terminal accommodates wires having a range of cross sectional areas, for example between 4 sq. mm & 25 sq. mm. Other ranges may be used.

Alternative termination means are capable of being fitted whereby to ensure the widest acceptance by different electrical supply utilities.

Termination means may comprise a clamp arrangement that provides adequate contact pressure by means of a clamping arrangement that does not screw into the wire directly. The terminal block and screw length are preferably dimensioned to provide a depth of at least three full screw threads within the block for all wire diameters specified.

In an alternative termination arrangement connection to the wire is made directly via two screws (for example, M8 screws for connecting cable up to 35 sq. mm or M6 for connecting to cable up to 25 sq. mm). The terminal block is again preferably dimensioned to provide a depth of at least three

full screw threads of the relevant screw type for all wire diameters specified.

In a preferred embodiment, terminal blocks (503, 503A, 510) are made of brass (complying for example with BS 2874 (in accordance with BS 7657)) which may be coated, if required, to provide general corrosion protection and to ensure that the connections with the wires have an electrochemical potential of less than 600 mV for both Copper and Aluminium conductors (Annex J of EN 60950 has a table of electrochemical potentials). The contact surfaces and threaded parts will not deteriorate under the environmental conditions of normal service. The terminals are so constructed that the conductors can be clamped between suitable surfaces without any significant damage either to conductors or terminals.

Preferably, the live and neutral terminal blocks (503, 503A) are provide with means for penetrating surface corrosion on the mains cables, particularly where the cables are of aluminium. Specifically, such means is provided in the form of ridges (932, 932A) running the length of the cable channel of the terminal blocks.

In a preferred embodiment, all terminal assemblies are captive within the device both for ease of installation and safety.

In a preferred low-cost option, contact with the mains conductor wires is achieved by direct screw termination on to the wire. For some markets, for example Germany, direct screw termination onto the wire is not acceptable, so that a clamping plate (506, 506A) is provided between the clamping screws and the wire itself .

Electrical segregation of the mains connectors is provided by insulating barriers between the adjacent terminal assemblies. These barriers prevent inadvertent bridging of conductors. These barriers are preferably integral parts of the housing construction, so that there is no danger of their becoming detached.

The design also significantly reduces the likelihood of the connection means between the Mains Connection Part and the Signal Coupler Part to short out between any of the connections.

The mains coupling part of the unit provides a method for connecting to the high current availability electricity supply. It also provides for connecting to the RF Coupling Part and thereby coupling of the modulated digital data.

The nominal mains supply voltage can be 230 V AC rms, 50 Hz or 60 Hz.

The RF signal to be injected onto the mains supply, and the RF signal from the mains supply is assumed to have an amplitude of 5 V AC rms and have a fundamental frequency in the range 2MHz to 6 MHz.

In order to ensure adequate coupling of the RF signal to (and from) the mains supply the unit should be mounted no more than 500 cm from the House Service Cut-out.

The ac mains supply at the point where this unit connects is Installation Category IV per IEC 664-1 and yet the secondary must be Installation Category I (see section 4.2 for further details). Certain power utility companies do not like voltage dependant devices across the mains supply and so it is necessary to place such devices in the secondary. This is a different approach to that adopted on the Phase 1 project.

The mains interface section of the unit supports a method for interconnecting to the high current availability electricity supply and outputting a low current availability connection to the RF section of the unit.

A fuse having a short circuit rupture capability to BS 88 is fitted in series with the live connection between the Mains Connection Part of the Power Tap and the RF Coupling Part. This fuse is located as close as possible to the incoming live terminal.

The equipment is preferably arranged for use in a number of countries, some of which have IT power systems, some of which have TT power systems, and some of which (for example the UK) have both. To achieve these ends the unit provides an interface that can couple signals either from phase to ground or from phase to neutral. For this reason the mains connection part will have provision for connecting to the Live, Neutral (or PEN), and Protective Earth mains terminals.

The unit is preferably designed to facilitates the manufacture of production variants that do not have all three terminations fitted; for example by omitting the Neutral connector.

Depending on which country the product will be installed in, and depending on the type of supply connection (TT or TN) the PCB may be configured accordingly. For example, in the UK using a TN power distribution system, it is anticipated that the neutral terminal will not be fitted and that on the PCB the neutral connection will be linked to the Protective Earth connection. In Germany, using a TT power system, it is anticipated that all three terminal blocks will be fitted and there will be no shorting link fitted from the Neutral to the Protective Earth on the PCB.

The RF coupler interface has provision for connecting to the Live, Neutral and Protective Earth terminations. These connections are terminated on the PCB in the RF coupler part of the interface. The unit is designed in a way which facilitates the building of production variants that do not have all three connections to the terminations fitted.

In a preferred embodiment, the coupler has an insertion loss <3dB over the frequency range of 2MHz to 6 MHz and customer-side data connection to the coupler is achieved via a 50Ω female BNC type connector mounted on the RF enclosure.

A bi-directional voltage breakdown circuit is fitted in the secondary circuit. This protects against transient voltages that appear between across the output of the transformer (differential mode). The circuit must have a low enough capacitance in its "Off" condition to present negligible loss to the RF data signal. Optionally (depending on what components or links are fitted) it is possible to either directly connect the BNC shell to Protective Earth directly, to connect it via a voltage breakdown device, or to float it. This option facilitates connection for a number of different countries and situations.

Because of the high level of transients at the ac mains, and the capacitance of the coupling transformer, the secondary circuit can suffer from transients from transients between the RF connection and protective earth. These transients can be reduced to acceptable levels by clamping one side of the transformer directly to ground, or clamping it to ground with a voltage dependant device. In most cases, clamping using a voltage

dependant resistor will be the preferred approach because this provides protection from transients while allowing the earth connection of the Coupling Unit to be at a slightly different potential (due to Rise of Earth Potential within an equipotential zone).

This PCB is a two layer board constructed from FR4 glass fibre with 1oz copper finished with solder resist and a silk-screen layer.

In one particular embodiment the overall external dimensions are approximately 75 mm high x 75 mm wide x 141 mm long (excluding any protruding data connector), and the weight of the fully assembled coupling unit is approximately 0.5 kg.

Corrosion resistance of materials and finishes may be varied to be used consistent with the local equipment life requirements. Plating is preferably selected such that the galvanic voltages between dissimilar materials are less than 0.4 volts. The interface between connector and bulkhead will have resistivity of less than 0.5 mohm.

The signal coupler contains no active devices. The internal components are preferably rated to operate at up to 80°C temperature.

IEC 664-1 details the transients that should be assumed to exist at various points in the mains distribution network for the purpose of ensuring adequate insulation co-ordination.

Any range or device value given herein may be extended or altered without losing the effect sought, as will be apparent to the skilled person for an understanding of the teachings herein.

CLAIMS

1. A mains power line signal coupler circuit comprising

a mains connection section,

a coupling section, and

a data connection section

wherein the data connection section comprises transient suppression means arranged to suppress transients originating from the mains connection section.

2. A circuit according to claim 1 wherein the transient suppression means is connected across the data terminals of the coupling section.

3. A circuit according to claims 1 or 2 wherein the transient suppression means comprises a voltage clamping diode within a diode bridge.

4. A communications network in which power and communications signals are carried over power lines, and comprising a signal coupler circuit according to any of claims 1-3.

5. A signal coupler comprising:

a mains connector part and

a signal coupler part,

wherein said parts are separable one from the other and arranged to provide electrical connection between said modules.

6. A signal coupler according to claim 5 wherein the mains connector part comprises at least one mains connector and a housing therefor, and the signal coupler part comprises a signal coupler circuit and a housing therefor.

7. A signal coupler according to claim 6 wherein the signal coupler circuit is according to claim 1.

8. A signal coupler according to any of claims 5-7 wherein a mains connector is arranged enable lead-though connection to a mains supply cable.

9. A signal coupler according to claim 8 wherein Live and Neutral mains connectors are each arranged to enable lead-though connection to a mains supply cable.

10. A signal coupler according to any of claims 8-9 wherein the mains connector comprises a opening cover and cable clamping means.

11. A signal coupler for coupling telecommunications signals between telecommunications equipment and a mains power cable, comprising a closed insulated housing, a first connection terminal mounted in a housing and having a channel for accommodating the mains power cable conductor, a clamp for clamping the conductor in the channel, the housing supporting a second connection terminal for connection to an earth lead and a third connection terminal for connection to the telecommunications equipment, the housing enclosing a circuit connected between first, second, and third terminals enabling telecommunications signals to pass between the first and third terminals and isolating the mains supply voltage from the third terminal.

12. A method of installing a signal coupler according to claim 5 comprising the steps of:

providing a signal coupler and a length of mains cable;

baring a mid-portion of said mains cable;

opening the cover of a mains connector of said signal coupler unit;

locating said bared section of mains cable along said mains connector;

closing the cover of said mains connector;

clamping said bared section of mains cable by clamping means of said mains connector.

13. A method according to claim 21 wherein the signal coupler unit is according to any of claims 5-11:

14. A method of removing a signal coupler unit according to any of claims 5-11 comprising the steps of :

detaching the signal coupler part from the mains connection part;

attaching a blanking cover in place of said signal coupler part.

15. An signal coupler according to claim 5 comprising a power line connector comprising

cable clamping means

and arranged to accept, retain by said clamping means, and make electrical contact with a bared mid-portion of an electrical cable which cable is elsewhere retained by arbitrary means towards each end of said cable.

16. An signal coupler according to claim 15 wherein the electrical connector is arranged to accept, retain by said clamping means, and make electrical contact with and between bared end-portions of two electrical cables.

17. An signal coupler according to claim 15 wherein the electrical connector additionally comprises cable surface corrosion penetrating means.

18. An signal coupler according to claim 17 wherein the electrical connector cable surface corrosion penetrating means comprise ridges formed on a cable-facing surface of the connector.

19. An signal coupler according to claim 18 wherein the ridges are formed parallel to the line of insertion of the electrical cable.

The Patent Office

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Application No:	GB 9805732.6	**Examiner:**	B.J.SPEAR
Claims searched:	1-4	**Date of search:**	14 October 1998

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.P): H4R (RTC)

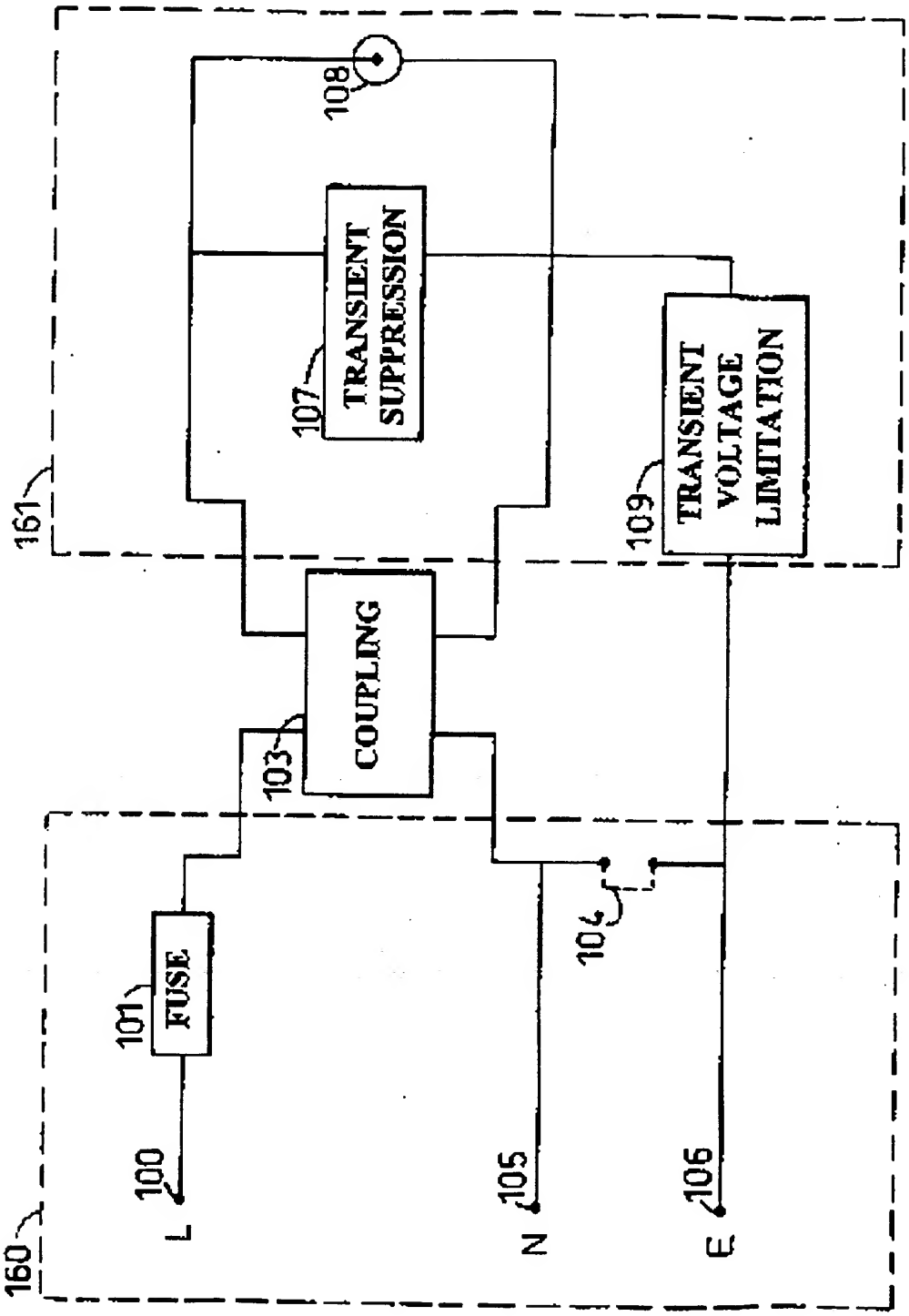
Int Cl (Ed.6): H04B 3/56

Other: Online:WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	GB2313273A	(Northern Telecom) Whole document, eg Fig. 2 ,unit NCU, and pages 11-12-especially p 11 ll 7-8.	1,2,4
X	GB2304013A	(Norweb) Whole document, eg Figs. 6-8 and p 10 l 9 to p 14 l 7, claim 1.	1,2,4
X	GB2139053A	(GEC) Whole document, eg the Figure and p 1 103-106.	1-4
X	GB1441945	(Felten) Whole document, eg the Figure and p 2 ll 12-21, p 3 l 3-4.	1-4
X	EP0111604A1	(Sharp) Whole document, eg Fig. 1 and p 3 ll 10-11, p 5 l 11-17	1-4
X	WO90/13950A1	(Abraham) Whole document, eg Fig. 1 and p 4 l 8 to p 5 l 21, p 15 l 20 to p 16 l 23.	1,2,4

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.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100
101
FUSE
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COUPLING
104
105
106
107
TRANSIENT SUPPRESSION
108
109
TRANSIENT VOLTAGE LIMITATION

Fig. 1

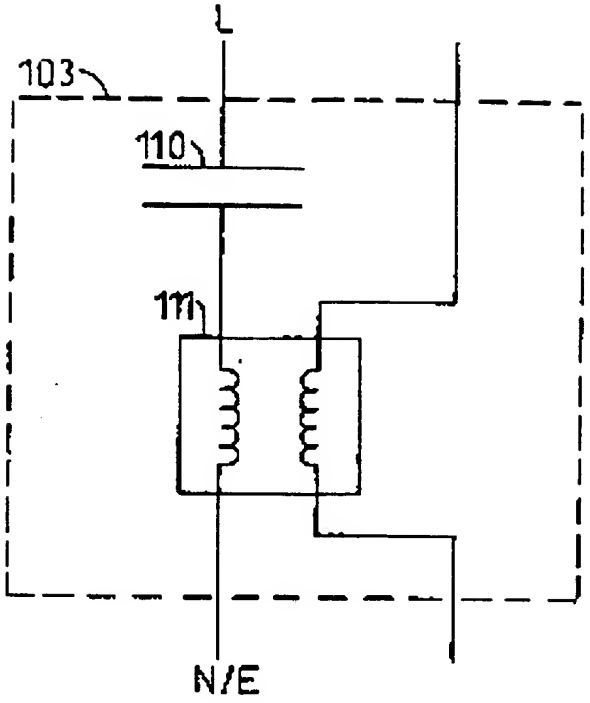


Fig. 1a

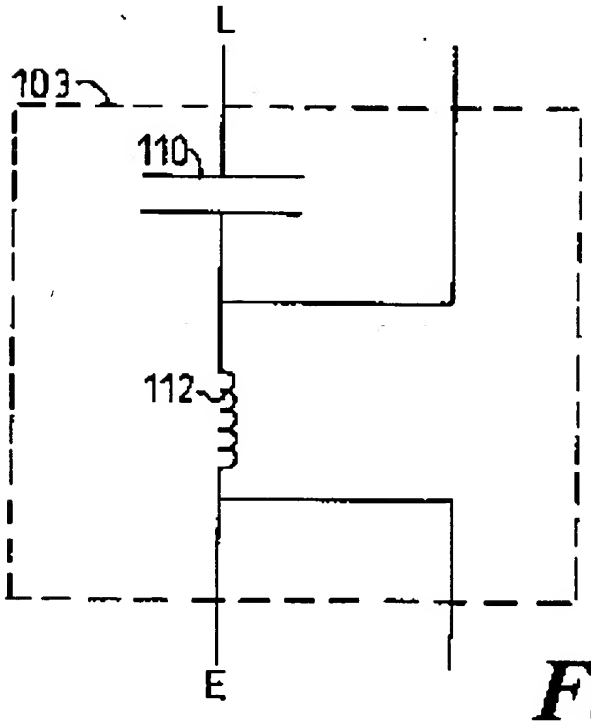


Fig. 1b

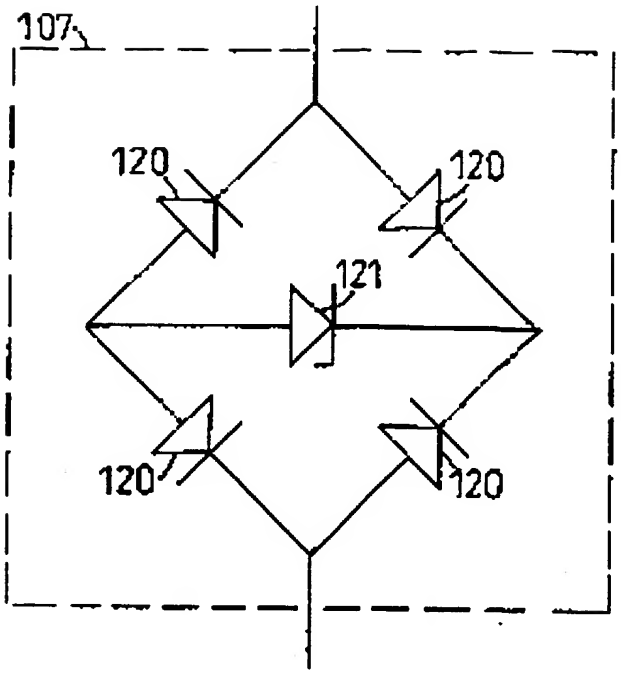


Fig. 1c

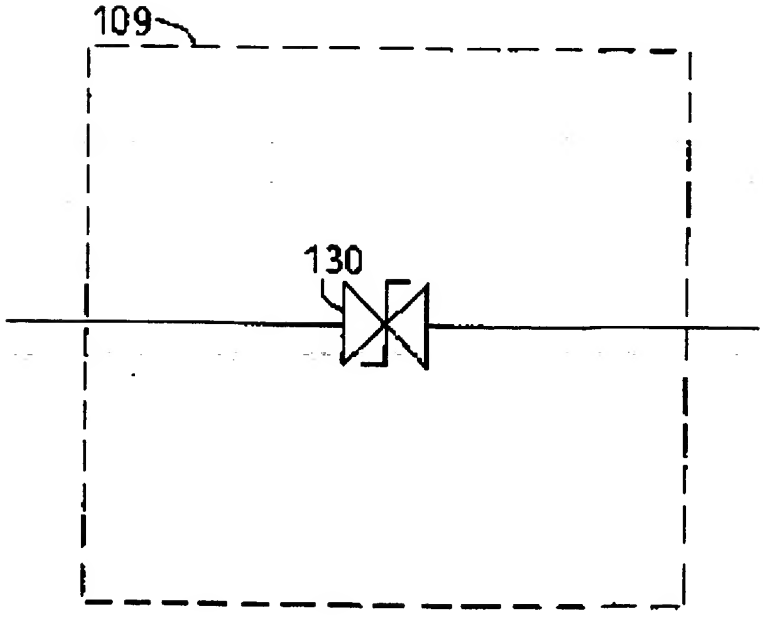


Fig. 1d

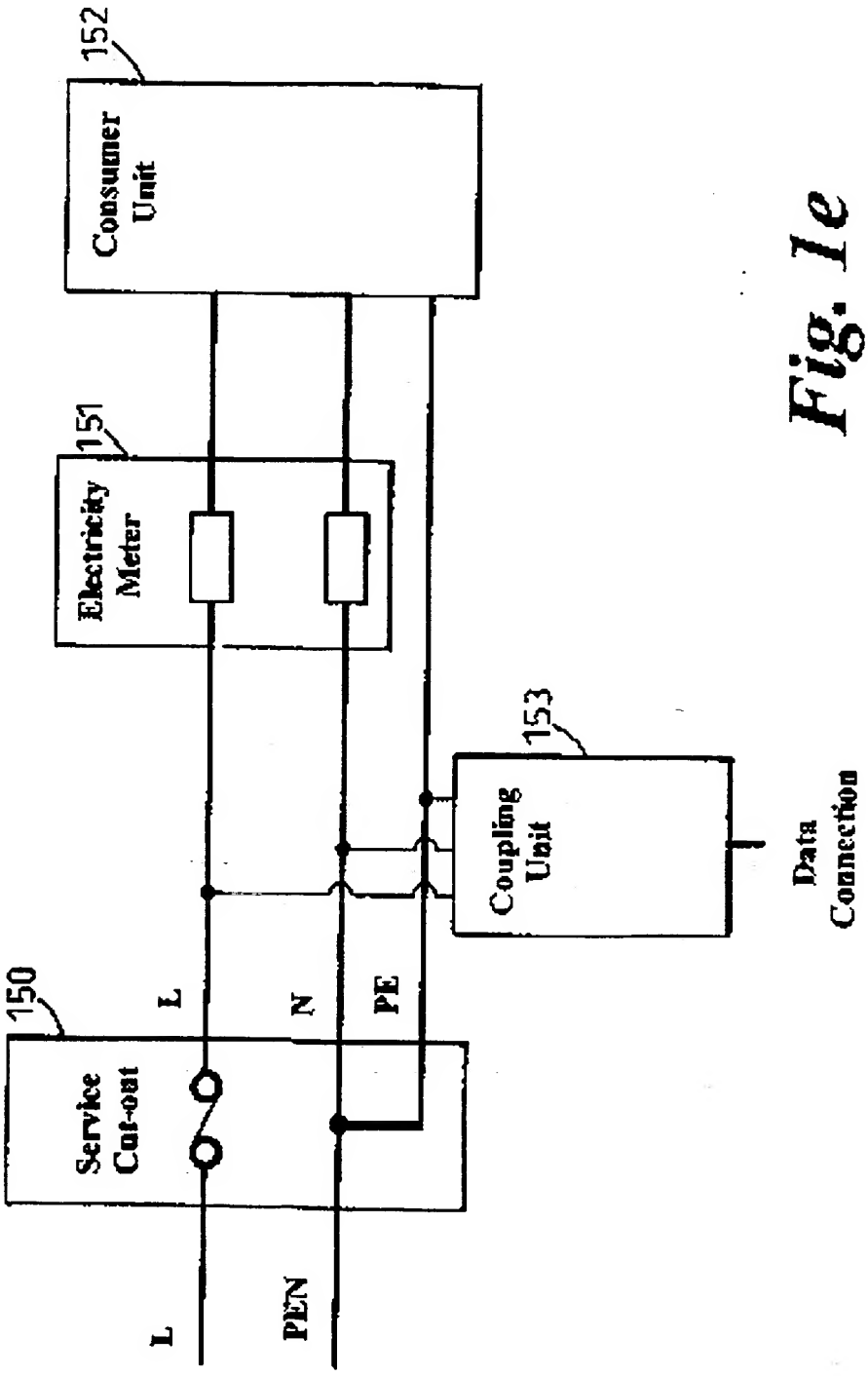


Fig. 1e

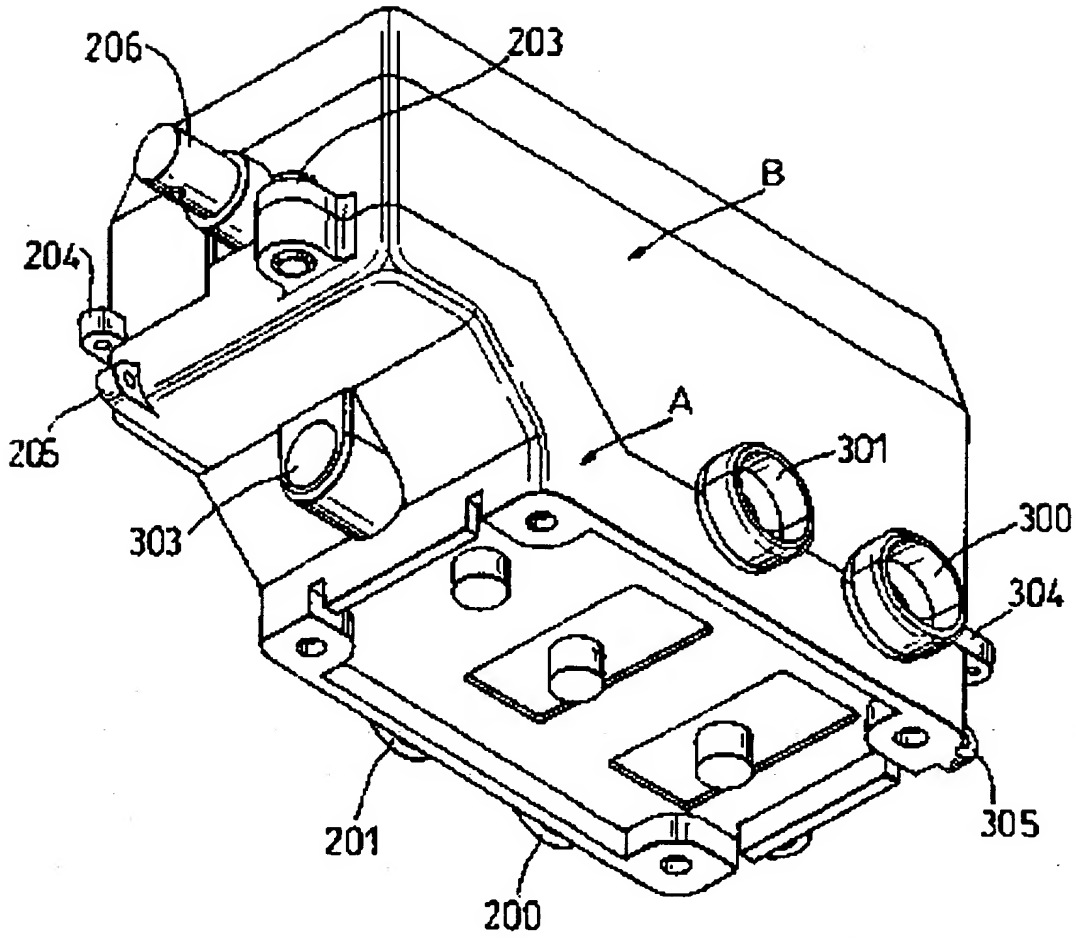


Fig. 2

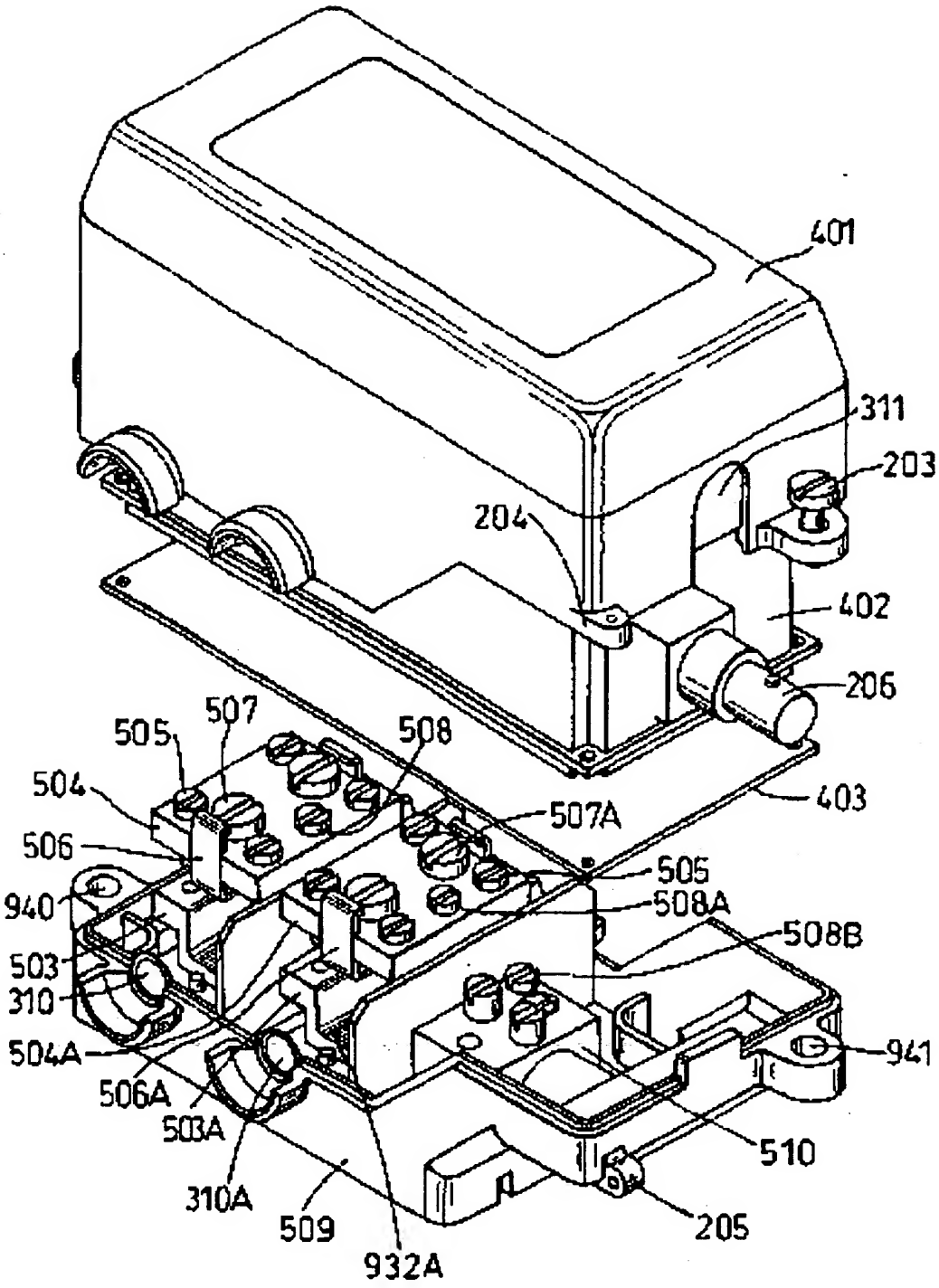


Fig. 3

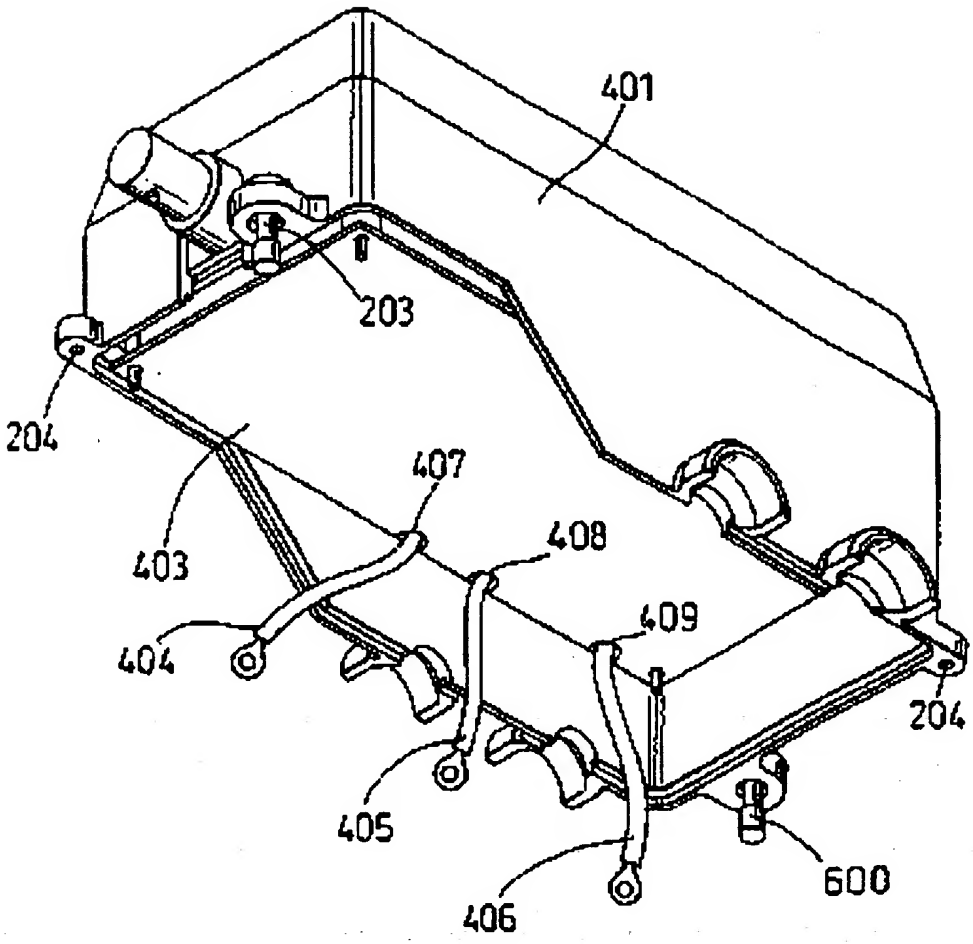


Fig. 4

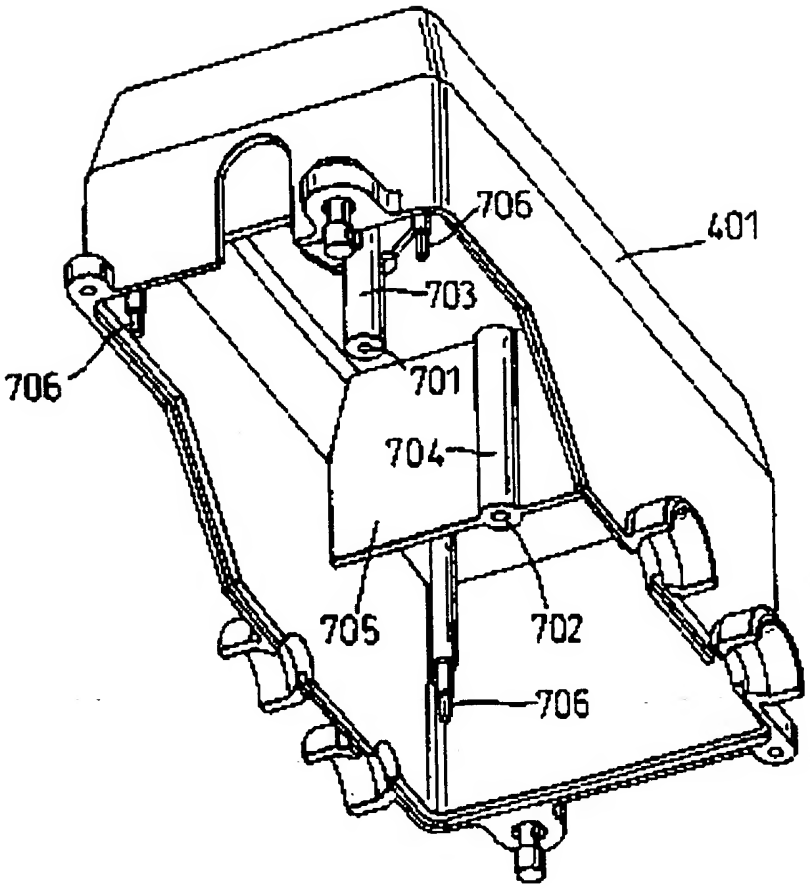
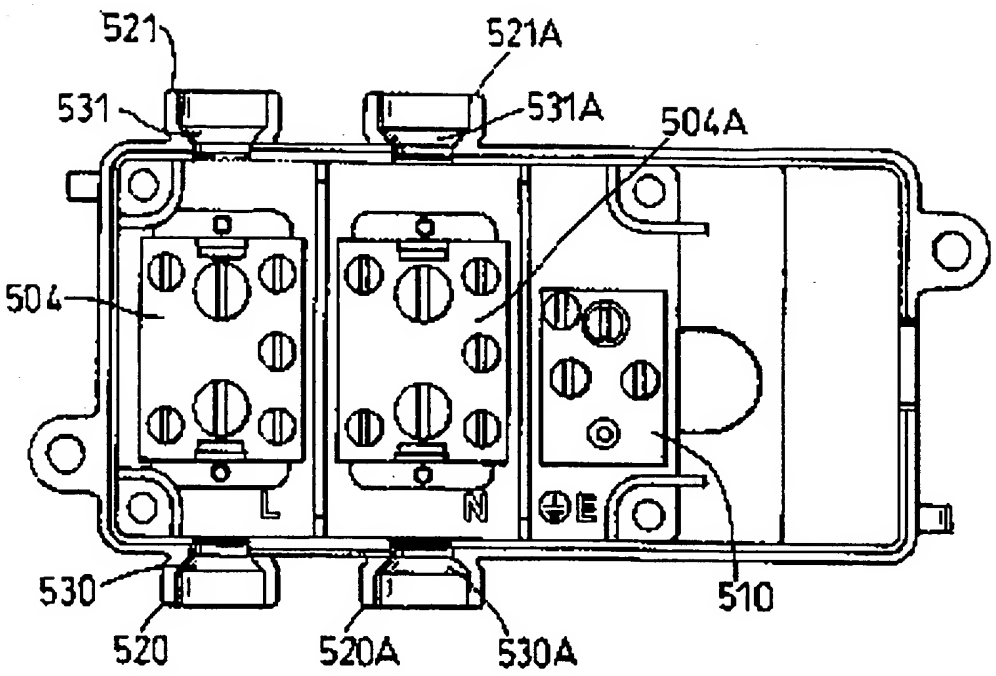


Fig. 5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504A
504
L
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E
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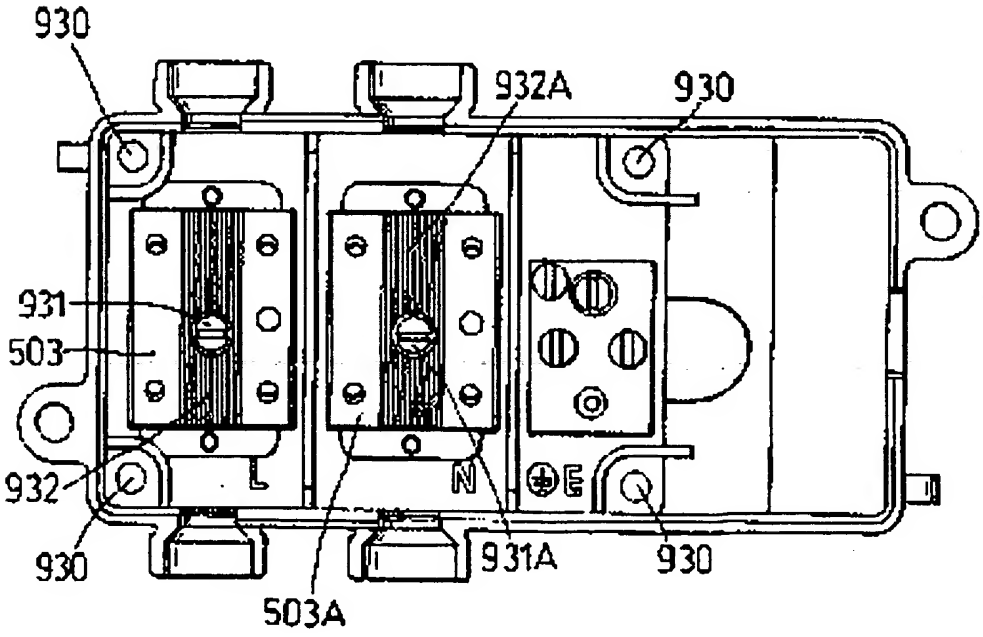
510
520
520A
530A

Fig. 6a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931A
930
503A

Fig. 6b

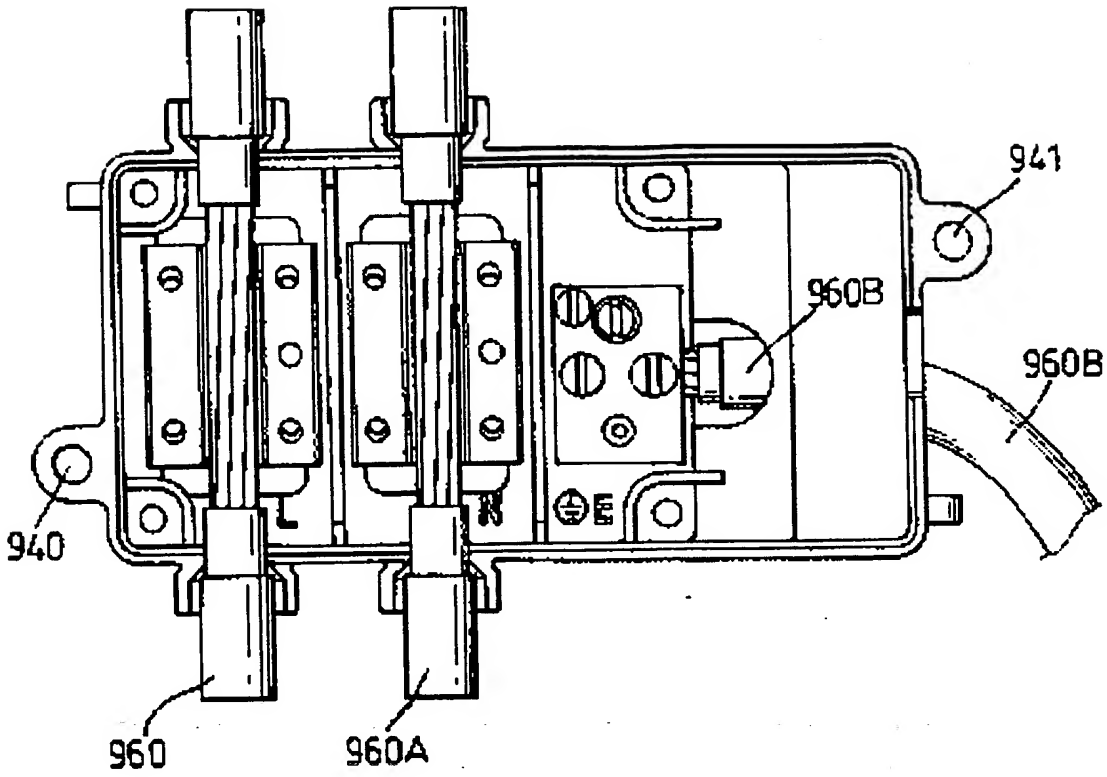

Fig. 6c